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Original Research

# Analysis of site selection in the industrial zones based on environmental and economic models: a case study of Arvand industrial zone of Iran.

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**ABSTRACT:**

Today, due to the potential of support job opportunities and exports as well as the need of the other producing and service sectors, the manufacturing industry is important to develop a country's economy. However, the establishment of industry encompassed environmental changes that could adversely affect the ecosystem. In this study, the accuracy of the selected locations for planned industries in Arvand industrial zone are determined based on the environmental shift and share economic models. The results showed that Arvand zone possesses required economical and industrial infrastructure; this region has not met any ecological incapability factors. Moreover, it doesn`t comply with defined environmental regulations such as proximity of factories to each other and their location relative to prevailing wind direction. Therefore, focusing on commercial and tourism developments are recommended instead of excessive industrialization.

**Keywords:**

Site selection, industrial zone, shift and share economic model, environmental models

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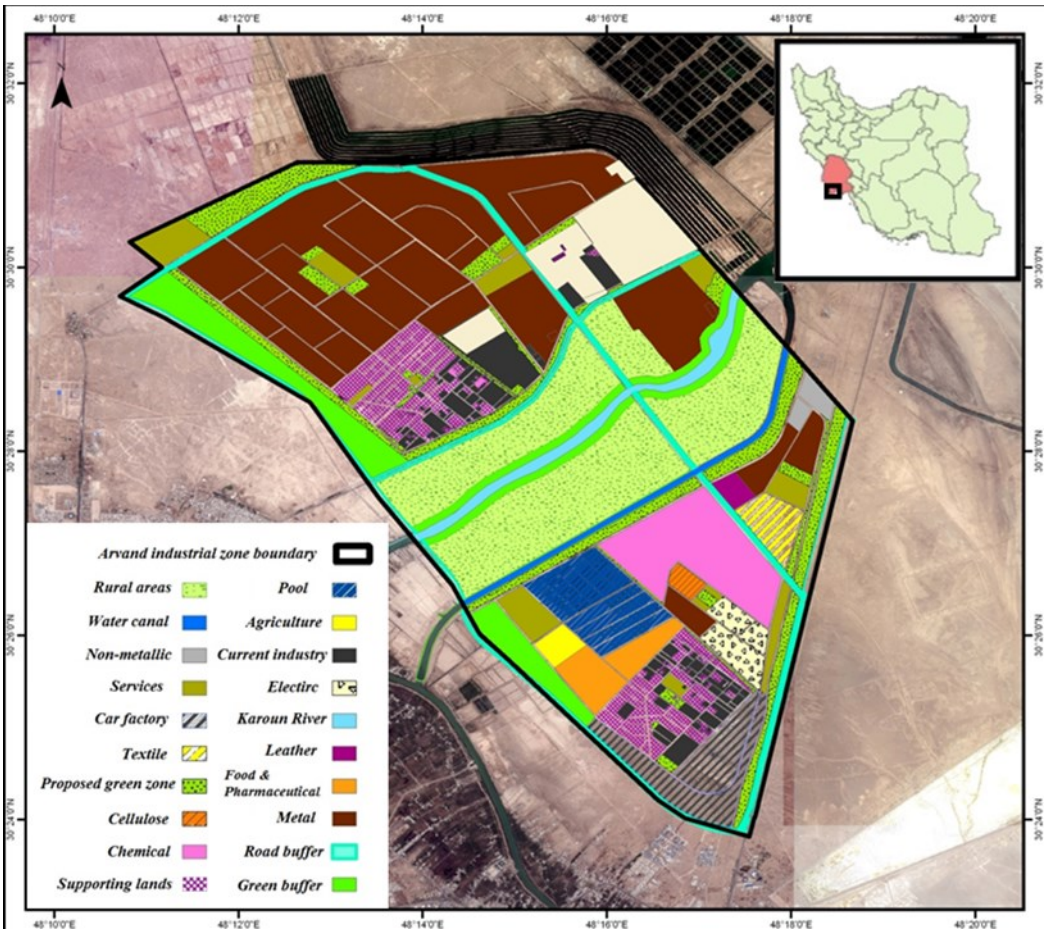
## INTRODUCTION

The high rate of land change has been increased greatly over last decades, as human populations continue to grow and migrate (Alig *et al.,* 2004; Theobald, 2005; Hasanzadeh and Daneshkar, 2014). Urbanization growth rate has caused the aggregation of different types of industries in urban areas which are allocated to prepare human needs (Hasanzadeh and Daneshkar, 2014).

Industrialization is an important factor that drives economic development. Thus, industrial sites are the areas that are affected by severe economic activities and high consumption of resources (Kang and Xu, 2012; Hazra and Acharya, 2015). In Iran, the general policies are formulated based on employment creation in the various sectors of economy, especially industry (Jalali and Javidan, 2010; Zangiabadi and Ahangari, 2012) However, industrialization force mankind to occupy and alter natural land covers to manmade ones and consequently release their solid and water wastes to earth (Hasanzadeh and Daneshkar, 2014; Grimm *et al.,* 2008). In other words, the establishment of industry encompassed environmental changes (Dabiri *et al.,* 2013; Mosaferi *et al.,* 2014) that could adversely affect the ecosystem.

During the last three decades, several authors have developed diverse assessment frameworks that integrate a number of dimensions required for sustainable development, which is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987; Santibanez-Aguilar *et al.,* 2014). Therefore, performing of environmental studies in the beginning of each project is one of the most important measures to achieve sustainable




**Map 1. Current and planned land use**

**Table 1. The proximity of industries to each other (DoE, 2012)**

| Industry-type | Proximity with other industries |
|---|---|
| Cellulose | Between non-contaminated and pollutant industries. Adjacent to electrical, textile, metal and non-metallic industries. |
| Metal | Between non-contaminated and pollutant industries. Adjacent to non-metallic, chemical and cellulose industries. |
| Food and Pharmaceutical | Towards prevailing wind direction. Adjacent to textile, electric and cellulose industries. |
| Electric | At the beginning of the prevailing wind direction. Adjacent to textile, pharmaceutical and cellulose industries. |
| Textile | Adjacent to wastewater treatment plant, electric, pharmaceutical, chemical and cellulose industries |
| Chemical | At the end of the prevailing wind direction. Adjacent to metal, non-metal and cellulose industries. |
| Non-metallic | At the end of the prevailing wind direction. Adjacent to metal, chemical and textile industries |
| Leather | At the end of the prevailing wind direction. Adjacent to metal, non-metallic, chemical and cellulose industries |

development (Sharifzadegan and Fathi, 2005; Shamsipour and Sheikhi, 2010; Cucek *et al.,* 2012; Shamsipour *et al.,* 2013). Site selection and industries establishment analysis based on environmental and economic models are a part of these studies.

Optimal site selection is one of the important factors to reduce competition and production costs, in addition to minimizing environmental impacts. Thus, the suitable site provides an optimal condition in a competitive market environment (Mokhtarian and Hadi-Vencheh, 2012).

Since, identifying limitations and carrying capacity of environment as a part of site selection are important to prevent harmful activities, the ecological capability of the region should be evaluated (Makhdoum, 2010; Yasouri, 2013). Site selection and environmental capability are new subjects of considerable government concern (Jafari and Karimi 2005; Rezai and Garmsiri, 2014).

The industrial parks based on sustainable development coordinate the objectives of urban and economic planner on environmental goals (Nasrolahi and Salehi, 2012). In addition to, it is the most effective measures of industrial ecology and sustainable development (Gibbs and Deutz, 2007; Fernandez, 2009) and a key factor to achieve strategic and operational objectives (Stevenson, 1996; Mai, 1981; CII, 1999; Kuo *et al.,* 2013).

In general, site selection process is a complicated subject that includes technical requirement with environmental, political and socio-economic needs (Eldrandaly, 2003; Cai *et al.,* 2015, Hazra and Acharya, 2015) which force the decision makers to consider a variety of investment and operating factors (Witlox, 2003). Actually, environmental capacity paves the foundation for sustainable economic development (Zhang and Hao, 2016). Thus, ecological capability evaluation facilitate the performing sustainable development as it`s foundation (Li *et al.,* 2011; Makhdoum, 2010; Jalilian and Danekar, 2011).

In this study, the accuracy of the selected locations for planned industries in Arvand industrial zone are conducted based on the environmental and economic indicators.

## MATERIALS AND METHODS

### Study area

The study area is Arvand industrial zone, located about 85 Km from Ahvaz, 22 Km from Abadan and about 12 Km from Khoramshahr city. Karoun River and Mard canal (Jian) divide this industrial site to west and east sections. Within only 2 Km from Arvand industrial site and there located eastern boundaries, Shadegan

**Table 2. Industrial activities' status of Khuzestan province related to the Shift and Share model**

| Industry | Value Added 2000 year | Value Added 2009 year | National Growth Share | Industry mixed share | Regional share | Rank |
|---|---|---|---|---|---|---|
| Food products | 216875518 | 43691722 | 13260183 | 12555533 | 543813 | 19 |
| Textile, leather | 1393038 | 3875877 | 851759 | 266810 | 454982 | 4 |
| Paper products | 172239 | 2009009 | 105311 | 59971 | 701 | 14 |
| Wooden products | 59046 | 194980 | 36102 | 145769 | 4672 | 16 |
| Paper and publishing products | 178368 | 116483 | 109058 | 7635 | 182463 | 28 |
| Manufacturing coke, refined petroleum products | 5283511 | 6727788 | 3230445 | 3030756 | 52694 | 26 |
| Chemical products | 11189626 | 22269737 | 6841562 | 8641860 | 614874 | 3 |
| Plastic products | 79506 | 288602 | 48611 | 66994 | 35531 | 13 |
| Other non-metallic mineral products | 718710 | 2362012 | 439434 | 510291 | 64064 | 12 |
| Fundamental metal products | 3693970 | 4691870 | 2258567 | 6383962 | 4894724 | 30 |
| Metal products except machinery equipments | 281442 | 1298312 | 172079 | 209184 | 337312 | 3 |
| Products and equipments machinery | 84866 | 436347 | 51889 | 15116 | 112272 | 6 |
| Counting and calculating machines | 0 | 0 | 0 | 0 | 0 | 13 |
| Other electric machines | 43191 | 317072 | 26408 | 24065 | 44752 | 8 |
| Manufacturing radio television and other communication instruments | 0 | 134493 | 0 | 0 | 0 | 20 |
| Manufacturing medical and optical instruments | 9966 | 45691 | 6093 | 3303 | 3561 | 8 |
| Manufacturing of motor vehicles, trailers and semi-trailers | 12632 | 162331 | 7724 | 11457 | 47539 | 9 |
| Manufacturing other transport equipments | 37313 | 93905 | 22814 | 27319 | 36163 | 26 |
| Manufacture of furniture and other products | 65316 | 432154 | 39936 | 125671 | 39843 | 3 |
| Recycling | 1676 | 35150 | 1025 | 13797 | 132 | 25 |

wildlife refuge that are assumed to be the nearest sensitive ecological region.

Currently over 50 percent of the study area is dedicated to barren land. Settlements and palm gardens cover 20 percent of this area and the other major land use are industries, aquaculture pools, prison, telecommunication site, combined cycle power plant agriculture, etc., Map 1 showed the industrial site's location and current planned land uses.

**Analyses methods**

In this study, the accuracy of the selected locations for planned industries in Arvand industrial zone are studied based on the economic indicators and environmental models including ecological capability evaluation and environmental regulations in terms of proximity of factories to each other and the standard distance of industries from settlements and natural habitats.

**Economic model**

Since, the case study is located in the northwest of Persian gulf, where Arvand and Karoun rivers are joined, as well as in neighborhood with Iraq and Kuwait, this area is always strategically important. In addition to, an abundant supply of water by Bahmanshir, Karoun and arvand rivers are obtained, being near international boundaries and available national and international transportation system such as railroad, shipping and aviation are the noticeable economic indicators that have significant role in site selection.

In this study, the Shift and Share model developed by Dan (1960) as a method to participate regional growth (Esteban, 2000) was used to investigate

**Table 3. Environmental factors and ecological capability of Arvand industrial site**

| Factor | | Factor characteristic's in ecological carrying capacity levels | | | Factor characteristic's in the region | Arvand site's capability according to the factors |
|---|---|---|---|---|---|---|
| | | Class 1 | Class 2 | Inappropriate | | |
| Climate | Average precipitation (mm) | 500-800 | All climates except the ones which are classified in inappropriate class | Located in the path of Whirlwinds and seasonal winds, with wind speed exceeding 50 km per hour | 140- 160 | 2 |
| | Average annual temperature (˚C) | 18-24 | | | 25 | 2 |
| | Average annual humidity (%) | 60-80 | | | 45 | 2 |
| | Wind speed (km/ h) | >35 | | | 20 | 1 |
| Slope (degree) | | <6 | 6-9 | >9 | 0-2 | 1 |
| Height (m) | | 400-1200 | 0-400 , 1200-1800 | >1800 | 3 | 2 |
| Aspect | | east | north | south-west | plain | 1 |
| Geology | | Sandstone, basalt, alluvial sediments | Limestone slate and alluvial granite | Blind fault, visible fault, fault growth in marl, seismicity, flood plains and sand dunes | Sedimentary plains | 1 |
| Soil | Depth | deep | Shallow to moderate | Shallow sandy | deep | 1 |
| | Drainage | Good to complete | Moderate to good | Poorly drained | Poorly drained | 3 |
| Water quantity (lit/day) | | 225-300 | 150-225 | Less than 150 | >300 | 1 |
| Vegetation density (%) | | Less than 35 | Less than 50 | More than 50 or irrigated farm | Less than 10 | 1 |

region`s economy. This method breaks down employment growth into three components: National Share (NS), Industry Mix (IM) and Regional Shift (RS) (Blair, 1995; Ghavidel, 2012; Goschin, 2014; Hajinejad *et al.,* 2014).

National share measures by how much total employment in a local area increased because of growth in the national economy during the period of analysis. Industry mix identifies fast growing or slow growing industrial sectors in local area based on the national growth rates for individual industry sectors. Thus, a local area with an above- average share of the nation`s high-growth industries would have grown faster than a local area with a high share of low-growth industries.

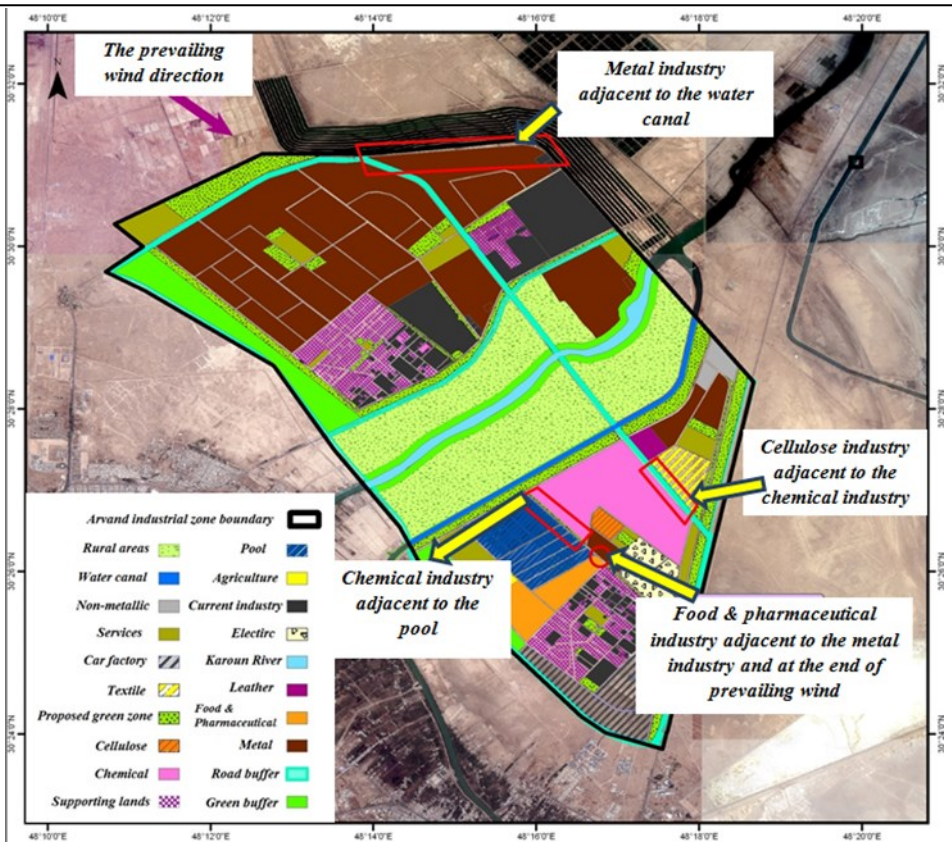
The Regional Shift (RS) or competitive effect is perhaps the most important component. It highlights a local area`s leading and lagging industries.

In this study, data from 10 years of Khuzestan province including product data (added value) of economic activities at regional and national levels were used to calculate NS, IM and RS *via* following formulates (Fajr Consulting Engineers, 2015):

$$1- \quad NGS = E_{ir}^{0} * \left(\frac{E_{tn}^{1}}{E_{tn}^{0}}\right)$$

$$2- \quad NGS = E_{ir}^{0} * \left(\frac{E_{itn}^{1}}{E_{itn}^{0}}\right) - \left(\frac{E_{tn}^{1}}{E_{tn}^{0}}\right)$$

$3- \quad \Delta E_i = NGS + IMS + RS$ = Production of activity (i) in region (r) in the beginning of the period




**Map 2. The proximity of industries in Arvand site**

$E_{ir}^{0}$ = Total production at the national level in the beginning of the period

$E_{tn}^{0}$ = Total production at the national level in the end of the period

$E_{tn}^{1}$ = Production of activity (i) at the national level in the beginning of the period

$E_{itn}^{0}$ = Production of activity (i) at the national level in the end of the period

$E_{itn}^{1}$ = The difference between production at the beginning and the end of period

$\Delta E_i$ **Environmental model and regulations**

The selected locations of industries in Arvand sites were analyzed based on ecological capability model and industry establishment regulations.

Environmental capability evaluation including ecological and socio-economic capability is a method to estimate the possible use of the land as agriculture, industry, service and commerce (Makhdoum, 2010; Pourjafar *et al.,* 2012). Accordingly, it is a potential capability of the land for development in relation to ecological capacity that can match the natural potential to the community need, land use and human activity in a logical way. The suggested ecological model was defined in two categories, suitable and unsuitable to investigate the industries location in which environmental factors including climate, physiography, geology, soil, hydrology and vegetation cover were considered in Arvand industrial site.

In addition to, the location of industries in Arvand site were compared with Human`s Environmental Laws, Regulations Criteria and standards of Iran in which proximity of factories to each other and the distance of industries from settlements and natural habitats were analyzed. Table 1 shows, how should the industries be placed adjacent to each other.

Since the site has been placed in the last class (class 6) of industry classification that their environmental impacts are more significant than the

**Table 4. The minimum standard distance of industries from settlements and habitats around the site**

| Settlements and centers | | | Distance to Arvand site | The minimum allowable distance (m) |
|---|---|---|---|---|
| Settlements | Province center | Ahwaz | 90000 | 2500 |
| | County center | Abadan | 2000 | 2000 |
| | | Khoramshahr | 1200 | |
| | City | Abadan | 2000 | 2000 |
| | | Khoramshahr | 1200 | |
| | | Moamareh Sangvar town | 400 | |
| | Village | Omo Talvil | 1200 | 1500 |
| | | Abbareh | 1800 | |
| | | Eastern Haffar | 1600 | |
| Health and education | | Moamareh Sangvar health center | 1200 | 1500 |
| Military Centers | | Police station- southwest of the site | 1000 | 1500 |
| | | Military area, west part of the site | 2000 | |
| | | Police station and emergency service, east part of the site | 100 | |
| National park and Wetland Lake National Natural Monument | | Shadegan wetland | 1700 | 2000 |
| Wild life refuge- protected area | | Shadegan wild life refuge | 400 | 1000 |

lower ranks, the strict rules are applied to investigate distance of industries from settlements and natural habitats.

## RESULTS

### Economic potential of the region

According to shift and share model, economic activities with competitive advantage can be identified as follows:

- If the regional share of an economic sector or series of activities is/are more than its mixed share and both numbers are positive; province or region has competitive advantage.
- If the regional share of an economic activity is positive and its mixed share is negative, this industry has competitive advantage potential.
- If the production change percentage of each economic sector at the local level is greater than the production change percentage of that sector at national level, that sector is pioneer and vice versa.

Table 2 shows the National Growth Share (NGS), the Industry Mixed Share (IMS) and Regional Share (RS) of economic activities of Arvand site. Using shift and share model, pioneer activities of the region were identified and ranked. Results indicated that top ranks belong to activities like chemical products, furniture and artifacts, manufacturing metal products except machinery and equipment, etc.

### Ecological capability of the region

Since the site is located within a homogeneous climate zone, there is no significant difference in the studied environmental factors. Thus, industrial units at Arvand site have equal establishment situations. Table 3 shows the ecological capability of Arvand industrial site compared with environmental factors.

As it can be resulted from the Table 3, the study area was classified as the 2$^{nd}$ class of industrial development in terms of climate factors including rainfall, temperature and humidity, and classified as 1$^{st}$ class compared with wind factor and landform of the site. However, due to the poor drainage conditions and high groundwater levels in site; inappropriate class has been chosen for it.

The proximity of planned industries to each other reviewing the location of chemical industries and

**Table 5. The minimum standard distance of industries from settlements and habitats within the site**

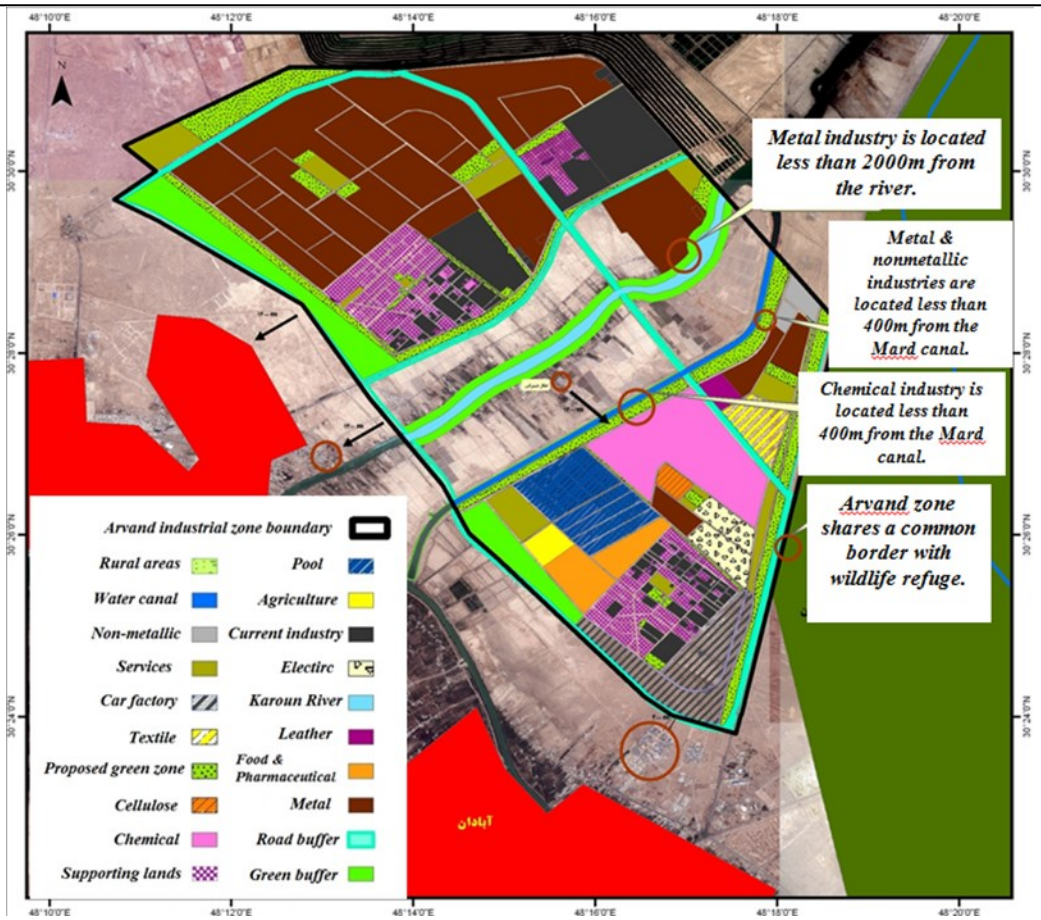
| Zone | Industry type | Settlements and centers | | Distance from the Arvand site | The minimum allowable distance (m) |
|---|---|---|---|---|---|
| Eastern coast of Karoun | Chemical | Eastern Haffar | Village Settlements | 1200 | 1500 |
| | | Western Haffar | | 2400 | |
| | | Karoun | Non drinking | 2000 | 500 |
| | | Mard Channel | permanent river | 380 | |
| | Leather | Eastern Haffar | Village Settlements | 3600 | 1000 |
| | | Western Haffar | | 1900 | |
| | | Karoun | Non drinking | 2200 | 250 |
| | | Mard Channel | permanent river | 300 | |
| | Metal | Eastern Haffar | Village Settlements | 4000 | 1500 |
| | | Western Haffar | | 2100 | |
| | | Karoun | Non drinking | 1700 | 500 |
| | | Mard Channel | permanent river | 260 | |
| | Non-metallic | Eastern Haffar | Village Settlements | 4800 | 1500 |
| | | Western Haffar | | 2800 | |
| | | Karoun | Non drinking | 1700 | 500 |
| | | Mard Channel | permanent river | 260 | |
| | Metal I | Eastern Haffar | Village Settlements | 3300 | 1500 |
| | | Western Haffar | | 1400 | |
| | | Karoun | Non drinking | 50 | 500 |
| | | Mard Channel | permanent river | 1500 | |
| | Metal II | Eastern Haffar | Village Settlements | 2000 | 1500 |
| | | Western Haffar | | 1700 | |
| | | Karoun | Non drinking | 1300 | 500 |
| | | Mard Channel | permanent river | 3200 | |
| Western coast of Karoun | Khorram shahr industrial park | Eastern Haffar | Village Settlements | 1000 | 1500 |
| | | Western Haffar | | 1800 | |
| | | Karoun | Non drinking | 1200 | 500 |
| | | Mard Channel | permanent river | 3000 | |
| | Saba combined cycle power plant | Eastern Haffar | Village Settlements | 1600 | 1500 |
| | | Western Haffar | | 1700 | |
| | | Karoun | Non drinking | 1100 | 500 |
| | | Mard Channel | permanent river | 3000 | |

existing region's land use showed that the proximity regulations has not been met, since the Shimi Shahr industrial site as a part of chemical zone is situated in the vicinity of aquaculture pools (at a distance of 150 meters from the north), as well as in west of the metal industries and south of Khuzestan heavy crude oil refinery.

Most parts of the chemical zone are located in the east of Mar channel and green belt of the site; therefore, establishment of Shimi Shahr industrial site in the vicinity of aquaculture pools which are categorized in agricultural industries are inconsistent with the establishment regulations.

Cellulose industry, located in Arvand industrial site is co-terminous with chemical industry in North and West, service zone in the east and metal industry in the south. Thus, according to the vicinity of cellulose and metal units, the unit's placement is incompatible with proximity regulations in Table 1 and cellulose industry is surrounded by pollutant industries.

Food and pharmaceutical industries are located in the southern part of the site, adjacent to agricultural zone, aquaculture pools, metal industry and Abadan industrial park. Comparing this spatial arrangement, Table 1 shows that the presence of metal industries in the




**Map 3. Industries location relative to the settlements and natural habitats**

northern area of the food and pharmaceutical industries conflicts with the proximity principles.

One of the existing industries in northern part of the site is electric industry, which is located in neighborhood to the chemical industry, service zone in the west, designed green space boundaries in the east and Abadan industrial park in the south. Accordingly, the vicinity with chemical industry and locating at the end of prevailing wind direction is in contrast with Table 1.

There is no conflict between other planned industries including metal industry, non-metallic and leather industries to the proximity regulations. Map (2) illustrates the proximity conflicts of planned industries.

**Environmental buffer zones of industries**

In order to investigate the environmental buffer zones, from the distance of Arvand site boundary, the current and planned industries from settlements and natural habitats have been assessed.

In Tables 4 and 5, the minimum standard distances of the site and the industries around Karoun river have been presented.

Since, the impacts of chemical, metal, food industries, car manufacturing, etc., ranked in industries of class 6, the minimum standard distance of this class has been considered to investigate the industries distance from the settlements and natural habitat.

As the data given in Table 4 represents the location selection of industrial units, the minimum standard distance from the settlements and natural habitats for some industries has exceeded the regulations. Among urban and rural settlements around the site, Khorramshahr, Moamareh Sangvar town and Omo Talvil village with 1200, 1000 and 400 meter distance to Arvand site, are located in less than the standard distance.

Shadegan wetland and wildlife refuge are 1700 and 400 meters far from Arvand site respectively. Besides, the distance of Shadegan wetland, which indicates that the minimum standard distance (2000 m) has been neglected; Shadegan wildlife refuge as well.

As previously noted, Karoun river and Mard canal pass through the site; eastern and western Haffar villages are around these water bodies, the distance of the industries from these settlements and habitats must be considered. Table 5 shows that some chemical, metal and non-metallic industrial units are located in less than the standard distance.

## DISCUSSION AND CONCLUSION

Current economic condition of Iran and the traditional methods of site selection in different parts of the country indicates that land use planning in national and regional scales has been ignored, and policies and lobbying have played an important role in land use planning in return. This created an overlay in authorities and loss of efficiency of industrial areas. (Rezai and Garmsiri, 2014; Shad *et al.,* 2009), whereas achieving proper regional development in each area required assessment and analysis of natural structures and human factors for each land use. (Ahadnejad *et al.,* 2013)

As it is mentioned, the location of Arvand industrial zone and its factories have been investigated according to potential of the area and environmental regulations of proximity and the minimum standard distance from the settlements and natural habitats.

Arvand industrial site has most of required infrastructures and economic potentials in general. According to the mentioned factors; it has access to target markets and cheap workforce as well. Despite all of these advantages, land of this area doesn't have all ecological factors for industrial development; for example poor drainage condition of the area, can bring about damaging effects for environment in the case of industrial development.

The results showed that some industrial units, especially chemical, cellulose, food and pharmaceutical have some contradictions with environmental regulations in terms of the factors such as proximity of each industry to others and its position to the prevailing wind direction. Since, distance from natural habitats and residuals are less than the minimum determined distances, it is necessary to pay more attention to the east and southeast boundaries of the site.

Although Arvand zone possess required economical and industrial infrastructure, this region has not met all ecological capability factors. Moreover, it doesn`t comply with defined environmental regulations such as proximity of factories to each other and their location relative to prevailing wind direction. Therefore, focusing on commercial and tourism development are recommended instead of excessive industrialization.

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